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APPLICATION TRANSFER ACTIVITY IN MISSOURI, JANUARY 1976 - JUNE 1978

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September 1978

Final Report



Prepared by

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16. ABSTRACT Experimental demonstrations and workshop instructional courses were conducted by the University of Missouri. The purpose was to transfer the technology of satellite remote sensing to a wide audience of resource managers in Missouri. This audience included planning commissions, state agencies, federal agencies, and special councils of the Governor. Some of the experiments and workshops are outlined. Other details have been previously published and are referenced.			
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INTRODUCTION

On January 10, 1975, NASA Administrator James C. Fletcher wrote to Missouri Governor Christopher S. Bond suggesting that satellite remote sensing might be beneficial to the State and inviting NASA-Missouri communications. Subsequent discussions with representatives of the University of Missouri led to a contract for a variety of technology transfer activities.

The contract NAS 8-31767 was initiated on January 5, 1976 and subsequently modified to extend through June 30, 1978. Contract objectives were to conduct research in the applications of satellite remote sensing data to land resource needs in the State of Missouri and to transfer results to state agency personnel.

The research included elements relating to geographic coding, land resource classification, identification of mined lands, application of additive color displays and diazo image processing, mineral industry liaison, computer image processing, and a variety of seminars, workshops and conferences.

PERSONNEL AND EQUIPMENT

The co-investigators of this project were assisted by many graduate and undergraduate students from the Rolla and Columbia campuses of the University of Missouri. They conducted individual experiments, helped prepare course and workshop materials, and assisted in various types of technology transfer activities. Several publications were authored by students. At several times during the study, Missouri State agency personnel cooperated in developing specific applications of remote sensing technology.

Two major items of hardware were acquired for use in this project. An I²S additive color viewer and a diazo printer-developer module were used extensively for preparing enhanced contrast landsat images. Both the additive color images and subtractive color diazo composites were successfully applied to the interpretation and delineation of mined land and land use cover categories.

TECHNOLOGY TRANSFER

Throughout the duration of the project, a variety of technology transfer activities were designed and executed. These activities included personal discussion, informal talks and invited lectures as well as organized conferences, seminars and workshops. Anyone who might have made an inquiry of The University of Missouri regarding applications of remote sensing most likely was referred to the investigators of this project on the UMC or UMR campus. Private, Local, State and Federal entities took advantage of the technology transfer activities fostered by this NASA project. The various organized activities conducted during the term of this project are summarized as to category and participating group as follows:

- A. Presentations and Seminars concerning remote sensing technology and potential applications in Missouri.
 - 1. Mid-Missouri, Mark Twain, Green Hills and Meramec Regional Planning Commissions.
 - 2. Nine regional Soil and Crop Conferences.
 - 3. Governor's Agricultural Council.
 - 4. Mid-Missouri Rural Development Committee.
 - 5. Governor's Advisory Committee on the Inventory of Surface Mined Lands.
 - 6. Missouri Interdepartment Council for Natural Resources Information.
 - 7. U. S. Forest Service
 - 8. U. S. Park Service
 - 9. Soil Conservation Service
 - 10. Remote Sensing Committee of the Missouri Interdepartmental Council.

- B. Workshops and Conferences concerning in-depth treatment of remote sensing applications.
 - 1. Two one-day remote sensing applications workshops for Missouri Regional Planning Commission Personnel.
 - 2. Applications Workshop for UMR and UMC students and staff.
 - 3. Applications of Landsat imagery workshop for the Association of Missouri Science Teachers.
 - 4. "Remote Sensing in the Future of Missouri Mining" workshop and seminar for member companies of the Mining Industry Council of Missouri.
 - 5. Cooperative Extension in-service remote sensing training workshop for agronomists and urban planning personnel.
 - 6. "Development of Land Resource Data and Interpretation" seminar for soil scientists and agronomists.
- C. Technical assistance concerning applications of remote sensing to on-going projects and activities has been extended to the following groups and agencies on a continuing basis:
 - 1. Missouri Department of Conservation.
 - 2. Missouri Geological Survey.
 - 3. Missouri Interdepartmental Council.
 - 4. Missouri Cooperative Extension Service.
 - 5. Soil Conservation Service.
 - 6. U. S. Forest Service.
 - 7. U. S. Geological Survey.

As materials were prepared for the variety of groups and agencies receptive to learning more about remote sensing applications, it became apparent that there was a need for written study guides and manuals. Participants in seminars and workshops requested summary documents covering specific application topics. In response to these needs, several reports and manuals were prepared so as to facilitate technology transfer activities. The sources of reports listed as follows are included in Appendix A.

1. Mapping Land Cover from Satellite Images: A Basic, Low Cost Approach.
2. Evaluation of Landsat Imagery for Mined Land Studies.
3. Techniques for Using Diazo Materials in Remote Sensor Data Analysis.
4. A Manual for Inexpensive Methods of Analyzing Utilizing Remote Sensor Data.

A discussion of that work upon which the reports and manuals are based is presented in the research activities section to follow. Examples of materials developed for presentations and seminars as well as workshop outlines are presented in Appendix B.

INDICATORS OF SUCCESSFUL TECHNOLOGY TRANSFER

1. The Office of Administration of the State of Missouri has contracted with the University of Missouri on two occasions for the preparation of land use maps derived from the interpretation of remote sensor data.
2. The State of Missouri contracted for and has received state-wide Level I land use maps from the USGS LUDA (Land Use Data Analysis) Program.
3. The Missouri Department of Conservation has purchased a digitizer and is preparing to utilize digital image analysis in their activities.
4. The Missouri Department of Conservation has contracted for mapping of timber resources from remote sensor imagery on several occasions.
5. The Missouri Geological Survey of the Department of Natural Resources has utilized remote sensing technology on two occasions in conducting dam and lake inventory projects.

6. The State of Missouri established an Interdepartmental Council for Natural Resources Information. A sub-committee on Remote Sensing was formed and continues to maintain a liaison with the University of Missouri.
7. The University of Missouri has continued to develop the capability to teach and conduct research into applications of remote sensing. A digital image processing system has been purchased for use in the remote sensing laboratory at UMR.
8. The various Regional Planning Commissions in the State of Missouri have begun to consider Landsat and other forms of remote sensing data as a routinely available source of land use information.
9. Local, State and Federal Agency's personnel continue to request information and assistance relative to applications of remote sensing technology.

RESEARCH ACTIVITIES

As technology transfer activities developed, a concurrent research effort was expended so as to prepare relevant examples of applied remote sensing. Specific areas of study are described as follows:

Land Use Studies

This element of the project was based on a perceived need of Missouri agency personnel for a manual approach to Level I land use mapping that would (1) minimize time and cost, (2) not require any previous experience with satellite imagery and (3) not require specialized equipment. Eight students and one Research Specialist were involved in mapping Level I land use categories in Nine Missouri Counties.

The academic background of the team included areas of specialization in geography, forestry, agricultural engineering, geology and agronomy.

The counties selected for mapping were Ralls, Boone, Callaway, St. Charles, Phelps, Dent, St. Francois, Ste. Genevieve and Livingston (Figure 1). Ralls County is representative of many of the rural counties in Northeast Missouri. Also, it is located near the Clarence Cannon Reservoir site in adjacent Monroe County. The Clarence Cannon Reservoir construction began in 1974. Boone County is typical of many counties in Missouri that are experiencing accelerated urban growth within a historically rural landscape. Callaway County has a predicted land use change that will accompany the present construction of a Union Electric Nuclear Power facility in the southern part of the county.

St. Charles County was selected due to its strong mixture of urban and rural land uses. This county is one of the most rapidly urbanizing counties in the nation and will continue to be so with a new four-lane bridge being completed between it and adjacent St. Louis County. Phelps and Dent Counties are typical Ozark Region counties with strong shifting patterns in land use occurring with timber conversion activities. St. Francois and Ste. Genevieve Counties are on the edge of the Ozarks and have numerous mining activities with strong geologic influences on land use. Livingston County is a predominantly agricultural county that is typical of much of North Central Missouri.

High altitude color infrared coverage was available for all of the counties except Livingston County. This photography was also available to the students for ground truth purposes.

Figure 1



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Satellite images were selected at a scale of 1:250,000. These images were available in color infrared format from the University of Missouri - Rolla Library. Availability of USGS topographic sheets at a scale of 1:250,000 was another reason for selecting this scale of imagery.

The USGS topographic sheets provided the base maps for developing overlays showing drainage, roadways and civil boundaries. These maps are also readily available to most potential users of satellite images within the state. The importance of familiarity of scale to the user will be discussed later.

All of the students were involved in special sessions to make them familiar with the site that they were mapping and the images which they would be using in the mapping task. Each student was assigned to map one county at a Level I or greater land use detail. Image orientation was accomplished on an individual basis after the students had been through classroom sessions on the principles of remote sensing, data collection systems, and application of remote sensing.

An average of one and one-half hours per student was spent on the image orientation phase. The orientation covered topics such as aspect and orientation of the LANDSAT images, scale, identification of specific cultural and natural features, introduction to color tones and delineation of the study site (one county per student).

All of the above topics were covered with each student but two different approaches were used. Half of the students were shown black and white ASCS photo indexes (1:60,000) of their county followed by orientation to the LANDSAT images. The other half were shown the LANDSAT images first followed by orientation on the black and white photo mosaics.

The students were asked to map land uses such as forest, urban, row crop and pasture on the black and white mosaic. Assistance was given to the students in recognizing these land use categories. After the student was proficient at outlining these categories, then they were shown the LANDSAT image and asked to recognize the same land use category at the same location shown on the black and white photos.

It was noted that the students who were exposed to the satellite images were able to map more rapidly on the images initially than the students who were shown the black and white photos first. There was confusion with the changes of scale from the black and white to the smaller scale of the satellite images. This confusion of scale is a very serious matter. The adjustment to the satellite image scale was much more rapid due to the use of the USGS topographic sheets of the same scale. The mental adjustment downward or upward of scale for most users is extremely difficult.

After the orientation to the LANDSAT images, each student prepared a 1:250,000 scale acetate overlay of their assigned county using the USGS topographic sheets. Difficulties were experienced in a number of the counties where more than one topographic sheet needed to be mosaiced to provide complete county coverage. The loss in accuracy was not a serious problem but it is an error that must be considered.

Two types of materials were used for overlays. Some of the students used a frosted acetate (mylar) that would accept both pencil and ink. The use of a pencil made the mylar easier to work with but the frosted treatment obscured the image to a degree that it was difficult to interpret. The contrast in color tones were greatly reduced and therefore

the advantage of the use of a pencil was decreased. The other students used a specially treated clear acetate which accepts both rapidograph and colored ink. The ink can be removed and corrections made with little difficulty.

Several different approaches were used in drafting the overlays. Seven of the nine overlays were prepared by drawing in the county boundaries and major highways and streams. This was sufficient to accurately place the overlay on the image with registration accomplished by natural features or a registration mark. The other two county overlays were prepared by drawing all of the above features plus roadways including state, federal and major county roads. This approach was useful in orientation but caused difficulty in interpretation, because it tended to clutter the map. The students solved the problem of cluttering by preparing a separate overlay for the county road network that could be overlayed for orientation and removed during the mapping process. This procedure is very beneficial to the user who is very knowledgeable about the county which he or she is mapping.

The mapping for each county was accomplished in three distinct stages. Stage 1 involved an in-depth mental assessment of the image with special attention to the county area to be mapped. Preliminary associations between color tones and the natural and cultural features were noted.

Stage 2 involves the delineation of land use categories which are easily recognized. This map phase provides a generalized map with no serious attempt made at detailed accuracy. Stages 1 and 2 greatly enhance the interpreter's feeling and understanding of the landscapes which are

being mapped and provides the basis for developing a more detailed map. If a person has not attempted a generalized map but begins immediately to draw in details, he may become frustrated and fail to accomplish his mapping tasks satisfactorily.

Stage 3 is the development of a more detailed map. Usually this involves remapping the categories which were generalized in Stage 2. A majority of the students produced a composite map showing all the categories that were differentiated. Two of the students accomplished their Stage 3 mapping with a series of overlays with one or two categories per overlay. This overlay approach was helpful to see individual land use categories but provides the possibility of error due to inaccurate registration.

It was noted that there were three different techniques or methods of interpretation employed by the students. Three persons mapped solely from the satellite images after establishing basic color tone and land use relationships through the use of the ASCS photo indexes. These students produced the least detailed maps but did achieve the most accuracy since they were using fewer categories. In other words, the categories were more generalized but provided very usable maps for most purposes.

Three persons used ASCS and NASA photography as guidelines through the mapping process but did not feel that they were strongly biased by the use of these materials. Their maps did provide more detail than the previous group. The remaining three persons relied heavily upon ASCS and NASA photography in evaluating and determining the categories that they were seeing on the satellite images. Several were seeing

Level II and some Level III types of land use categories. Sequential coverage of satellite images would probably eliminate the strong need for supporting aircraft photography.

Background data and supporting information were provided to the students to use in the mapping process. Such information as topographic maps, geology maps, soil maps, crop calendars, county highway maps, generalized land use maps and weather data are important to the mapping process. The more interpreters know about the area, the more they will see in the mapping process.

An example of the use of weather data was found in St. Charles County. Three and one-half inches of rain fell two weeks prior to the image acquisition. This encouraged farmers to perform early plowing of wheat stubble which showed up as dark blue areas and was easily confused with wetland areas. Students that were formerly residents of the county that they were mapping, appeared to make the most knowledgeable and accurate interpretations on their maps.

Experience is an important factor to consider in developing land use maps from satellite images. One's background is crucial to what one sees on the image. This brings forth the adage, "you see what you know".

The geologists had the most trouble with recognizing crops and pastures but it was noted that they along with the foresters were best at recognizing physical landscape features. Geographers were best at seeing cultural features and seeing the overall land use relationships. The agronomists performed the best interpretations of agricultural features such as soil patterns and cropping patterns but were weak on other categories.

Some of the students had the opportunity to use more than one satellite image over their area. These students had to become adjusted to the different color tones as well as the seasonal aspect of the landscape. It was also found that one needs to calibrate the color tones on a frame from one day to the next. Students who mapped during the same time of each day had the most consistent results. It was found that the most accuracy was achieved with one and one-half to two hours of interpretation time at one sitting. Encouragement was given to the students to map at the same time of the day for the same period of time each time that they mapped.

The psychological mood of the student was extremely important in the interpretative process. There were some days that the student could not concentrate or differentiate the categories. A student that partied the night before, was concerned about a test in one of his courses, or was concerned with something else besides mapping, would have a difficult time producing a good map. It is important to pick the time for mapping when one really feels encouraged to produce a good product.

The most rapid and accurate maps were produced by the students who mapped one category or color tone at a time. The student would not tire as easily in looking for one or two categories. This is actually using a logical search method in the mapping process.

The amount of time used to produce the mapped products were recorded. The experience of the individual student was a factor in the interpretative process. The orientation of the students to the mapping process required from five to ten hours. It took three to four hours for the students to produce the general map of the entire county. This included

a complete redrafting of the map to the students satisfaction. The more detailed map required ten to fifteen hours on the first attempt. All of the students redrafted or reinterpreted the detailed map which required from six to eight hours. Most users would likely be satisfied with the general map. There are other users who are only concerned with one specific land use and the detailed map for that purpose could be accomplished more rapidly with experience.

In addition to Manual Level I land cover mapping activities, a computer based methodology for interrelating land cover maps with general soil associations and slope data was developed. The basic objective was to enhance the value of separate but comparably scaled sources of information which, by themselves, are limited in utility by their generality. Data collection and mapping was carried out on a county basis. Individual maps were compiled at a scale of 1:250,000 for each land cover classification, soil association and slope category. Each map, in the form of a transparent overlay, was registered to a common base map. Individual overlays were optically digitized and the data stored on magnetic tape. Summary statistics were compiled by computer and reported in tabular form listing the acres for each land cover classification by slope category for each soil association. Boone County, Missouri was selected to test the methodology.

The general soils information employed in the study was taken from a new 1:250,000 state soil map compiled by the Soil Conservation Service and the Missouri Agricultural Experiment Station. Nine soil associations were delineated for Boone County. Separate maps for each soil association were overlayed on individual land cover maps.

The land cover maps were compiled from two sources. U.S. Geological Survey LUDA maps scaled at 1:250,000 were used for the urban, forest and disturbed classifications. A LANDSAT false color composite image scaled at 1:250,000 was used to separate hay and pasture areas from grain crop areas.

Additional information about the major soils in each association was obtained by interrelating the land cover information within each soil association with slope. Using U.S. Geological Survey 1:250,000 topographic maps, three slope maps were prepared for Boone County. Each map comprised a different slope class: upland or ridgetops 0 - 5%, sideslopes greater than 5% and bottom lands 0 - 5%. These maps were then overlayed on the soil association maps and land cover maps thus allowing an estimate of land cover by major soil type to be interpreted.

Through the use of the UMC Bioengineering Program computer facilities, all the maps were registered to a common base and digitized. A Spatial Data Model 108 Computer Eye was used to digitize all maps at a resolution of 256 x 240 points. A Ramtex GX 200 color display was used to assist in registration and display of the digitized maps. Nine tract 800 BPI tape drives and disk drives were used for image storage and retrieval as well as program development and storage. The PDP - 11 DOS operating system and programs utilized are primarily Fortran IV, with some special purpose assembly language subroutines. Table I shows the summary statistics generated for the test county.

Table II shows the number of acres of the individual land cover categories currently covering prime agricultural land in Boone County. The addition of this geocode to the data base was prompted by concern on

the part of city, county and regional planners over the loss of prime agricultural land to urban growth in Boone County.

In March of 1977, the Federal Energy Administration announced its support for the initial planning of two coal gassification plants in Missouri for converting high sulphur Missouri coal into electrical energy and pipeline quality gas. One of the planned 300 megawatt Combined Cycle Coal Gassification plants would be situated in the Mid-Missouri planning region which includes Boone County. Because local strip mining would be relied upon to supply the plant, a preliminary assessment of the amount and type of land cover overlying coal seems favorable for mining in Boone County was made. Individual map overlays of each favorable coal seam were compiled at 1:250,000 and entered in the data base. Table III shows the output for one seam.

The results of continuing land use studies were used successfully in a variety of training activities as indicated in the Technology Transfer section of this report. Also, a paper entitled "Mapping Land Cover from Satellite Images: A Basic how Cost Approach" was prepared and ultimately published as NASA Contractor Report 2952. See Appendix A for its source.

Mined Land Studies

The application of Landsat remote sensing to mined land studies served as the vehicle for investigating the utility of additive color viewing and diazo compositing in enhancing Landsat images. Study sites in Missouri for investigation of interpretation and enhancement techniques were selected as follows:

TABLE I

	CROPS	H&P	URBAN	DIST	FOREST	WATER	PRIME AG
<u>SOIL #1</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	43.5	0.0	0.0	87.0	0.0	65.3
Bottom Land	12245.6	1740.0	108.8	0.0	1305.0	0.0	14268.5
<u>SOIL #2</u>							
Ridge Top	369.8	3371.3	0.0	0.0	21.8	0.0	2175.0
Side Slope	217.5	2871.1	0.0	0.0	21.8	0.0	1152.8
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #3</u>							
Ridge Top	0.0	848.3	21.8	0.0	108.8	0.0	87.0
Side Slope	304.5	7025.4	369.8	0.0	195.8	0.0	21.8
Bottom Land	0.0	217.5	0.0	0.0	65.3	0.0	0.0
<u>SOIL #4</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	87.0	348.0	21.8	0.0	108.8	0.0	65.3
Bottom Land	3284.3	2001.0	65.3	0.0	783.0	0.0	4241.3
<u>SOIL #5</u>							
Ridge Top	33778.3	17052.6	5937.9	65.3	1500.8	43.5	40151.1
Side Slope	30428.8	12115.1	2088.0	217.5	3153.8	130.5	26274.6
Bottom Land	304.5	43.5	43.5	0.0	0.0	0.0	326.3
<u>SOIL #6</u>							
Ridge Top	0.0	1044.0	0.0	0.0	1587.8	0.0	0.0
Side Slope	369.8	12593.6	239.3	21.8	13768.2	0.0	1566.0
Bottom Land	413.3	478.5	65.3	43.5	804.8	0.0	913.5
<u>SOIL #7</u>							
Ridge Top	4458.9	15595.3	435.0	195.8	6329.4	65.3	4763.4
Side Slope	8091.2	63749.8	1435.5	4676.4	27884.1	195.8	7482.2
Bottom Land	130.5	3719.3	0.0	0.0	500.3	0.0	1131.0
<u>SOIL #8</u>							
Ridge Top	3545.3	2175.0	65.3	0.0	630.8	0.0	4110.8
Side Slope	4554.6	7068.9	0.0	0.0	3741.1	21.8	2283.8
Bottom Land	0.0	87.0	0.0	0.0	65.3	0.0	0.0
<u>SOIL #9</u>							
Ridge Top	326.3	12963.4	435.0	87.0	4415.4	0.0	348.0
Side Slope	2631.8	39868.3	3023.3	217.5	34169.8	195.8	3741.1
Bottom Land	369.8	1587.8	0.0	0.0	717.8	0.0	1261.3
TOTAL	106011.6	208608.4	14355.3	5524.6	101966.1	652.5	116430.1

TOTAL COUNTY AREA = 437120.0

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TABLE II
PRIME AGRICULTURAL LAND

	CROPS	H&P	URBAN	DIST	FOREST	WATER
<u>SOIL #1</u>						
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	43.5	0.0	0.0	21.8	0.0
Bottom Land	12071.6	1218.0	108.8	0.0	870.0	0.0
<u>SOIL #2</u>						
Ridge Top	217.5	1957.5	0.0	0.0	0.0	0.0
Side Slope	21.8	1109.3	0.0	0.0	21.8	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #3</u>						
Ridge Top	0.0	87.0	0.0	0.0	0.0	0.0
Side Slope	0.0	21.8	0.0	0.0	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #4</u>						
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	21.8	43.5	0.0	0.0	0.0	0.0
Bottom Land	2827.6	1131.0	0.0	0.0	282.8	0.0
<u>SOIL #5</u>						
Ridge Top	28928.1	7090.7	3784.6	65.3	239.3	43.5
Side Slope	23186.1	1892.3	609.0	43.5	478.5	65.3
Bottom Land	282.8	0.0	43.5	0.0	0.0	0.0
<u>SOIL #6</u>						
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	282.8	870.0	21.8	0.0	391.5	0.0
Bottom Land	369.8	239.3	21.8	43.5	239.3	0.0
<u>SOIL #7</u>						
Ridge Top	2240.3	2175.0	130.5	0.0	217.5	0.0
Side Slope	1348.5	5481.1	0.0	130.5	522.0	0.0
Bottom Land	65.3	1065.8	0.0	0.0	0.0	0.0
<u>SOIL #8</u>						
Ridge Top	3066.8	957.0	65.3	0.0	21.8	0.0
Side Slope	1827.0	435.0	0.0	0.0	21.8	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #9</u>						
Ridge Top	65.3	239.3	0.0	0.0	43.5	0.0
Side Slope	413.3	2436.1	174.0	0.0	696.0	21.8
Bottom Land	304.5	891.8	0.0	0.0	65.3	0.0
TOTAL	77540.5	29384.9	4959.1	282.8	4132.6	130.5

TOTAL COUNTY AREA = 437120.0
COAL SEAM AREA = 116430.4
SCALE FACTOR = 21.8

TABLE III

COAL SEAM #1 WHEELER - BEVIER MOST FAVORABLE

	CROPS	H&P	URBAN	DIST	FOREST	WATER	PRIME AG
<u>SOIL #1</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #2</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #3</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	739.5	0.0	0.0	0.0	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #4</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #5</u>							
Ridge Top	6981.9	4154.3	326.3	0.0	761.3	0.0	6416.4
Side Slope	4676.4	4176.1	282.8	0.0	413.3	0.0	2958.1
Bottom Land	21.8	43.5	0.0	0.0	0.0	0.0	0.0
<u>SOIL #6</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #7</u>							
Ridge Top	935.3	4176.1	195.8	43.5	3523.6	43.5	174.0
Side Slope	2305.6	18118.3	957.0	1696.5	12702.4	43.5	1957.5
Bottom Land	0.0	413.3	0.0	0.0	43.5	0.0	87.0
<u>SOIL #8</u>							
Ridge Top	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Side Slope	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>SOIL #9</u>							
Ridge Top	0.0	65.3	0.0	0.0	0.0	0.0	21.8
Side Slope	261.0	1087.5	0.0	0.0	195.8	0.0	0.0
Bottom Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	15181.8	32973.9	1761.8	1740.0	17639.8	87.0	11614.8

TOTAL COUNTY AREA = 437120.0

COAL SEAM AREA = 69384.3

SCALE FACTOR = 21.8

COAL SEAM #2 WHEELER - BEVIER FAVORABLE

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Coal mines (strip operations)-----	Boone County
-----	Calloway County
Lead Mine Tailings-----	St. Francis County
Barite Pits-----	Washington County
Clay Pits-----	Gasconade County

These sites were selected with the advice and cooperation of Mr. James Martin, Department of Natural Resources and Chairman of the Advisory Committee on Inventory of Surface Mined Areas in Missouri. Additional sites were selected from Landsat imagery covering southwest Illinois and the Kansas-Missouri border near Kansas City.

A procedural guide was prepared which outlined the steps for judging the applicability of satellite imagery for evaluating mined land areas. The general steps of the analysis were as follows:

- A. Evaluation of image Quality.
- B. Interpretation and identification of mined area.
- C. Interpretation and identification of mined land sub-classes.
- D. Preparation of delineated targets on 7-1/2 or 15 minute overlays to existing topographic bases.
- E. Evaluation of identification accuracy and cost of image acquisition and interpretation.

A mined land classification system was devised for implementation with satellite imagery as follows:

- A. Active Mine Site
 1. Stripped Area
 2. Spoil banks or gob piles
 3. Haul Roads
 4. Mine Structures

B. Inactive Mine Site

1. Reclaimed Land

a. Regraded Land

1. Grassland
2. Crop Land
3. Forested Land
4. Bare Soil

b. Ungraded

1. Grassland
2. Crop Land
3. Forested Land
4. Bare Soil
5. Water

2. Mine Waste Disposal Sites

- a. Tailings Ponds
- b. Spoil or gob piles

3. Permanent Water Impoundments

A number of filter and positive and negative image combinations were used with the I²S additive color viewer. Spectral enhancements were achieved which were successfully interpreted to yield mined land classes. The results of this element of the project were used in workshops and then summarized in a paper presented to the Missouri Academy of Science in April, 1977, entitled "Evaluation of Landsat Imagery for Mined Land Studies". See Appendix A for its source.

Diazo film enhancements of mined land areas and general land use categories were made in a study which was conducted in conjunction with the additive color viewer work. Similar types of ratioed enhancements were made utilizing subtractive color theory appropriate for diazo films.

This work culminated with a NASA Contractor Report 2953 entitled "Techniques for Using Diazo Materials in Remote Sensor Data Analysis." In response to a need for a basic interpretation guide, a manual entitled "Inexpensive Methods of Analyzing and Utilizing Remote Sensor Data" was prepared. This report was also published as a NASA Contractor Report 150731 during 1978. See Appendix A for the sources of these reports.

CONCLUSIONS AND RECOMMENDATIONS

All measures indicate that remote sensing technology has been successfully transferred to individuals and agencies dealing with natural resource data handling. The use of manual interpretation techniques has been stressed in seminars and workshops and is most likely being applied effectively. New potential users are being identified on a regular basis whereas those who have participated in past workshops are now anxious to learn more about digital image processing and applications of data base management systems. It would appear that an opportunity now exists to provide additional services in the form of computer processing seminars, workshops and conferences. Needless to say, many research opportunities exist for the development of applications.

APPENDIX A

LIST OF
PROJECT PUBLICATIONS AND REPORTS

Elifrits, C. Dale, Terry W. Barney, David J. Barr, and C. J. Johannsen.:

Mapping Land Cover From Satellite Images: A Basic, Low Cost
Approach. NASA Contractor Report 2952. 1978. *

Whitebay, Lee E., and David J. Barr.: "Evaluation of Landsat Imagery
for Mined Land Studies." Transactions, Missouri Academy of Science.
Vol. 10 & 11, pp. 195-199. 1977.

Whitebay, Lee E., and Shara Mount. : Techniques for Using Diazo
Materials in Remote Sensor Data Analysis. NASA Contractor Report
2953. 1978. *

Elifrits, C. Dale, and David J. Barr. : A Manual for Inexpensive
Methods of Analyzing and Utilizing Remote Sensor Data.
NASA Contractor Report NASA CR-150731. 1978. *

*NASA Contractor Reports are sold by the National Technical Information
Service, U. S. Department of Commerce, 5285 Port Royal Road,
Springfield, VA 22161; phone (703) 557-4870.

APPENDIX B

WORKSHOP OUTLINES AND ANNOUNCEMENTS



University of Missouri-Rolla - Extension Division

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WORKSHOP ON LAND RESOURCE MAPPING WITH REMOTE SENSING TECHNIQUES

May 17 & 18, 1976

Presented by:

University of Missouri-Rolla
Dept. of Mining, Petroleum & Geological Engineering
Dr. D. J. Barr and staff

University of Missouri-Columbia
Dept. of Agronomy
Dr. C. J. Johannsen & staff

Location: Bldg. D, Room 102, University of Missouri-Rolla (corner of 14th & State St.)

Parking: Lot No. 18

WORKSHOP SCHEDULE

8:30 a.m. - 8:45 a.m.	Introduction and Overview
8:45 a.m. - 9:45 a.m.	Remote Sensing Interpretation Equipment and Procedures
9:45 a.m. - 10:00 a.m.	Break
10:00 a.m. - 12:00 noon	Land Resource Mapping Methodologies
12:00 - 1:00 p.m.	Lunch Break
1:00 p.m. - 2:00 p.m.	Optimum Land Resource Mapping Techniques
2:00 p.m. - 5:00 p.m.	Use of Equipment and Example Mapping by Participants

Identical workshops to be held on May 17 and 18. -- Cost: \$12.00 per day

Location and lodging information on enclosed map.

-----Detach and Return Registration With Remittance-----

Pre-Registration Required (not later than May 13)

Name _____

Region _____

Address _____

I plan to attend:

City _____ State _____ Zip _____

May 17 _____

May 18 _____

Social Security Number _____
(For Continuing Education Units)

Fee - \$12.00 per day

Please make check payable to University of Missouri-Rolla and mail to Extension Division,
University of Missouri-Rolla, 501 West 11th Street, Rolla, Missouri 65401.

an equal opportunity institution

WORKSHOP ON LAND RESOURCE MAPPING WITH REMOTE SENSING TECHNIQUES

May 18, 1976

Remote Sensing Laboratory, Building D
Department of Mining, Petroleum, and Geological Engineering
University of Missouri-Rolla

WORKSHOP SCHEDULE

8:30 - 8:45 A.M.	Introduction and Overview
8:45 - 9:45 A.M.	Remote Sensing Interpretation, Equipment, and Procedures - Dale Hudson and Dale Elifrits
9:45 - 10:00 A.M.	Break
10:00 - 12:00 A.M.	Land Resource Mapping Methodologies Level I - Direct tracing techniques - Terry Barney, Virginia Michalbacker Level II and III Mirror Stereoscope and Microviewer techniques - Dale Elifrits Zoom Transfer Scope and Richard's Light Table techniques - Dale Hudson
12:00 - 1:00 P.M.	Lunch
1:00 - 1:45 P.M.	Optimum Mapping Techniques Panel Discussion: Dale Elifrits, moderator Dale Hudson, Virginia Michalbacker, Terry Barney as panel members
1:45 - 5:00 P.M.	"Hands On" training for participants with the imagery, photos, and equipment.

Subject: Identification of Mined Areas of Missouri - Preliminary
Outline

Date: 8 September 76

I. Areas to be studied and evaluated.

A. Landsat.

1. B/W Film Positive, 1:3,369,000.
2. B/W Film Negative, 1:3,369,000.
3. B/W Print, 1:500,000.
4. False Color Composite, 1:250,000.

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B. Color Infrared Photography.

1. High Altitude.
 - a. U-2.
 - b. Sky Lab.
2. Low Altitude (if available).

C. Color Photography.

1. High Altitude.
 - a. U-2.
 - b. Sky Lab.
2. Low Altitude (if available).

D. Panchromatic Photography - Low Altitude.

E. Diazochrome Composites.

F. Positive - Negative Composites (Masked Images).

II. Instruments to be used for the study.

- A. Additive Color Viewer (I²s Mini Addcol Viewer #6020).
- B. Zoom Transfer Scope (Bausch & Lomb # ZT4).
- C. Micro-Reader (Post).
- D. Zoom 240 Stereoscope System (Bausch & Lomb).
- E. Mirror Stereoscope.

III. Preliminary Test Sites - Location and type of mining taking place.

- A. Putnam Co., T65N, R17E, sec 1&2 - Coal, contour stripping.
- B. Henry Co., T41N, R28E - Coal, areal stripping.
- C. Barton Co., T30N, R33W - Coal, areal stripping.
- D. Boone Co., T50N, R12W - Coal, abandoned mine.
- E. Callaway Co., T49N, R11W - Coal, acid drainage.
- F. Gasconade Co., T42N, R5W - Fire Clay.
- G. Audrain Co., T50/51N, R8/9W - Fire Clay.
- H. Washington Co., T40N, R2E and T38N, R3E - Barite.
- I. St. Francois Co., T36N, R4/5E - Deep mines, tailings.
- J. Stoddard Co., T25/26N, R10/11E - Sand and Gravel.
- K. Wayne Co., T5N, R27E - Brown Iron Ore.

IV. Preliminary Targets - Categories to be mapped.

A. Active Mine Site - An area where mining was taking place at the time of the overflight.

- 1. Stripped area.
- 2. Spoil banks or gob piles.
- 3. Haul roads.
- 4. Mine buildings.

B. Inactive Mine Site - An area where mining has taken place however, no activity was recorded at the time of the overflight.

- 1. Reclaimed Land.
 - a. Graded, slope less than _____.
 - 1) Grassland.
 - 2) Cropland.
 - 3) Forested.
 - 4) Bare soil.

b. Ungraded.

1) Grassland.

2) Cropland.

3) Forested.

4) Bare soil.

5) Covered by water.

2. Mine Waste Disposal Sites.

a. Tailings Pond.

b. Spoil banks or gob piles.

3. Bodies of Water within the test areas.

V. Proposed Procedure.

A. Study each type of imagery independently.

B. Identify mined areas.

C. Identify as many targets as possible.

D. Prepare a map of the mined area from the imagery, (mylar overlays) using USGS 15 or 7.5 minute topographic maps as base maps.

E. Prepare a chart indicating which targets could be accurately mapped from each type of image.

F. Prepare a chart indicating the cost of using each type of image.

1. Cost of Procurement.

2. Cost of Interpretation and Mapping.

G. Prepare a slide show to aid in the presentation of the findings.

H. Prepare a written paper summarizing the results and presenting the conclusions drawn from this study.

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Remote Sensing in the Future of Missouri Mining

(Inventory and Reclamation)

TIME: Tuesday, March 15, 1977, 9:00 AM - 3:00 PM

PLACE: Ramada Inn, Jefferson City, Missouri

Seminar sponsored by Mining Industry Council of Missouri, School of Mines and Metallurgy - University of Missouri - Rolla and College of Agriculture - University of Missouri - Columbia.

This seminar is being conducted without cost to participants by the University of Missouri and the Mining Industry Council of Missouri with support from the National Aeronautics and Space Administration and the U.S. Department of Agriculture.

The seminar has been organized to provide the participant with an up-to-date review of how remote sensing technology (aerial surveillance) is being used to inventory mined lands and monitor the state of mined land reclamation. Remote sensing will be discussed with respect to type of sensor, nature of product, scale and resolution. Practical applications will be reviewed in light of the limitations of the technology. A seminar outline is provided on the back of this announcement.

REGISTRATION

Please register by 5:00 p.m., Mon., March 14, 1977

NAME _____

ADDRESS _____

PHONE _____

RETURN TO:

**Mining Industry Council of
Missouri
210 Monroe Street
Jefferson City, MO 65101**

Remote Sensing in the Future of Missouri Mining

(Inventory and Reclamation)

**Ramada Inn
Tuesday, March 15)**

- 9:00 a.m. Agriculture and Mining as Partners
Elmer Kiehl, Dean of Agriculture, UMC**
- 9:20 a.m. Establishing Vegetation on Disturbed Lands
Dr. Hal Wheaton, Extension Agronomist, UMC**
- 10:00 a.m. Coffee Break**
- 10:30 a.m. Missouri's Mined Land Inventories
James Martin, Geologist and Chief, Mineral Resources Data &
Research Section, Div. of Geology and Land Survey, DNR, Rolla**
- 11:00 a.m. Remote Sensing Technology Overview
Dr. David Barr, Assoc. Prof., School of Mines and Metallurgy, UMR**
- 12:00 p.m. Lunch**
- 1:00 p.m. Applications of Remote Sensing for Inventory and Reclamation
Dr. Chris Johannsen, Extension Agronomist, UMC**
- 1:45 p.m. Utilizing Satellite Images to Inventory Mined Land
Lee Whitebay, Research Assistant, Dept. of Mining, Petroleum and
Geological Engineering, UMR**
- 2:30 p.m. Questions and Discussion
Theodore J. Planje, Dean of School of Mines and Metallurgy, UMR**

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

You are invited to a seminar on:

DEVELOPMENT OF LAND RESOURCE DATA AND INTERPRETATION

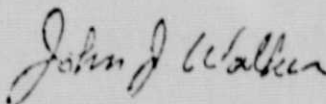
April 1, 1977 - 2:00 to 3:30 PM
USDA Conference Room
555 Vandiver Drive
Columbia, Missouri

The following people are on the program: Dr. William D. McFarland, Bioengineering and Advanced Automation Programmer, UMC; Dr. Chris Johannsen, Land Use Specialist, UMC; Terry Barney, Research Specialist in Agronomy and Ival D. Persinger, Assistant State Soil Scientist, USDA Soil Conservation Service.

Bill, Chris, Terry and Ival will present and explain a system for providing computer tabulated data for Missouri counties. The tabular data, based on digitized maps, can be generated from the computer. The maps that will be digitized into the computer are: 1 - General Soil Map, 2 - Slope Map and 3 - Land Cover Map.

Final tabulation gives number of acres of row crops, hay and pasture, forest, and water by ridgetop, side slope, and bottomland for each soil association in the county.

Potential users of such data are soil scientists, engineers, biologists, agronomists, foresters, appraisers, researchers and land use specialists.


Kenneth G. McManus **ACTING**
State Conservationist

SEMINAR AGENDA

INTRODUCTION..... JIM LEE

GENERAL SOILS MAP AND SLOPE MAP COMPILATION..... IUAL PERSINGER

LAND COVER MAPPING..... TERRY BARNEY

GEOGRAPHIC REFERENCING..... IUAL PERSINGER

DIGITIZING AND COMPUTER STORAGE..... BILL MCFARLAND

APPLICATIONS, ACCURACY AND COSTS..... IUAL PERSINGER
TERRY BARNEY
BILL MCFARLAND

COMPUTER TABULATED DATA
FOR MISSOURI COUNTIES

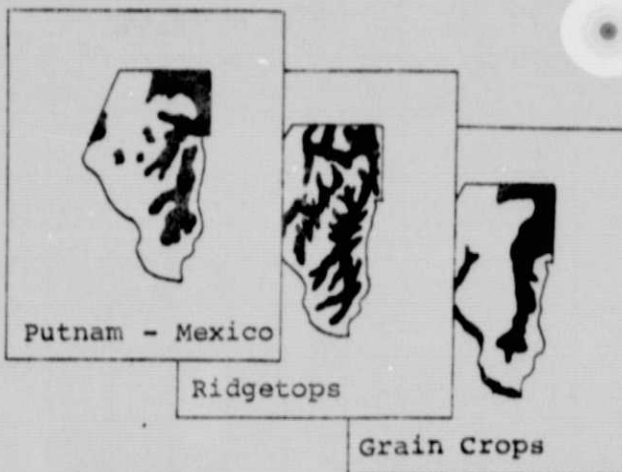
STEP 1 DATA COLLECTION AND MAPPING

Individual maps are compiled at a scale of 1:250,000 for each soil association, slope category and land cover classification. For Boone County, 9 soil associations, 3 slope categories and 5 land cover classifications were mapped for a total of 17 maps.



STEP 2 GEOGRAPHIC REFERENCING

Each of the 17 maps, in the form of a transparent overlay, is registered to a common base map.



STEP 3 DIGITIZING AND COMPUTER STORAGE

Each overlay is digitized and the information is "stacked" in the computer for storage.

STEP 4 DATA RETRIEVAL

Summary statistics are reported in tabular form showing the number of acres for each land cover classification by slope categories for each soil association in the county.

March 28, 1977

BOONE COUNTY SOIL MAP, SLOPE MAP, AND VEGETATIVE COVER INVENTORY

MAP UNITS	Grain Crops (C)	Hay & Pasture (P)	Forest (F)	Disturbed Land (D)	Urban (U)	Total Acres
Haynie-Leta-Waldron (1)						
Ridgetop (R)	0	0	0	0	0	0
Side Slope (S)	0	0	71	0	0	71
Bottom (B)	11,536	382	2,316	47	0	14,281
	11,536	382	2,387	47	0	14,352
Seymour-Lagonda (2)						
Ridgetop (R)	95	2,794	0	0	0	2,889
Side Slope (S)	95	2,603	143	0	0	2,841
Bottom (B)	0	0	143	0	0	143
	190	5,397	286	0	0	5,873
Pershing-Armstrong-Gara (3)						
Ridgetop (R)	0	621	71	0	71	763
Side Slope (S)	143	5,422	525	0	597	6,687
Bottom (B)	0	47	310	310	0	667
	143	6,090	906	310	668	8,117
Kennebec-Nodaway-Colo-Zook (4)						
Ridgetop (R)	0	0	0	0	0	0
Side Slope (S)	167	0	0	0	0	167
Bottom (B)	2,842	1,576	1,074	23	0	5,515
	3,009	1,576	1,074	23	0	5,682
Putnam-Mexico (5)						
Ridgetop (R)	37,190	13,877	1,528	0	3,630	56,225
Side Slope (S)	30,812	11,274	3,582	95	883	46,646
Bottom (B)	167	71	931	931	143	2,243
	68,169	25,222	6,041	1,026	4,656	105,114

MAP UNITS	Grain Crops (C)	Hay & Pasture (P)	Forest (F)	Disturbed Land (D)	Urban (U)	Total Acres
Menfro-Winfield-Lindley (6)						
Ridgetop (R)	0	1,743	716	0	0	2,459
Side Slope (S)	238	17,078	9,148	0	0	26,464
Bottom (B)	836	644	1,361	71	0	2,912
	1,074	19,465	11,225	71	0	31,835
Weller-Keswick-Lindley-Mandeville (7)						
Ridgetop (R)	4,944	14,450	5,541	119	23	25,077
Side Slope (S)	6,807	65,829	27,588	3,129	764	104,117
Bottom (B)	0	716	406	119	0	1,241
	11,751	80,995	33,535	3,367	787	130,435
Hatton-Keswick-Lindley-Goss (8)						
Ridgetop (R)	3,057	1,910	668	0	0	5,635
Side Slope (S)	3,582	7,834	4,371	0	0	15,787
Bottom (B)	0	47	191	119	0	357
	6,639	9,791	5,230	119	0	21,779
Weller-Goss-Gasconade (9)						
Ridgetop (R)	262	14,307	4,466	95	143	19,273
Side Slope (S)	2,937	53,623	28,041	191	1,051	85,843
Bottom (B)	47	716	501	23	0	1,287
	3,246	68,646	33,008	309	1,194	106,403
TOTAL	105,757	217,564	93,692	5,272	7,305	429,590

Source of Information:

1. State general soil map - Soil Conservation Service and University of Missouri Agricultural Experiment Station
2. Slope map - USGS 1:250,000 topo map
3. Vegetative cover - University of Missouri Extension Service, Landsat color composite 1:250,000
4. Computer analysis - University of Missouri, Bioengineering and advanced automation program

Conf. 30 Remote Sensing Applications in Extension Programs

Agenda

Wednesday, April 6, 1977

Bldg. D, Room 102, University of Missouri - Rolla

- 1:00 p.m. Introduction and Overview of Remote Sensing
- Definitions
 - The Electromagnetic Spectrum
 - Types of Remote Sensing Systems
 - Types of Data & Information Products
- 2:15 Ground Truth
- 3:00 Coffee Break
- 3:30 Data Analysis - Photo Interpretation and Measurements
- 5:00 Adjourn

Thursday, April 7, 1977

- 8:30 a.m. Data Analysis - Computer and Machine Processing Techniques
- 9:30 Applications of Remote Sensing
- Soil Mapping
 - Crop Identification
 - Forestry
 - Geology & Engineering
 - Land Use & Development
 - Corn Blight Watch Experiment
 - Large Area Crop Inventory Experiment (LACIE)
- 11:00 Land Use Data Analysis (LUDA) - Mr. Jerome Berry
U.S. Geological Survey, Rolla
- 12:00 Lunch - Zeno's Restaurant
Speaker - Dr. Tom Beveridge, Prof. of Geological Engineering
"Theoretical and Applied Rhabdomancy"
- 2:00 Remote Sensing Systems of the Future and Future Educational
Experiences in Remote Sensing - Mr. Wayne Mooneyhan, Director
Earth Resources Laboratory, NASA
- 3:00 How to Map Land Use in Your Extension Area
(Hands on experience with equipment, images & mapping techniques)
- Conference Coordinators and Instructors - Dr. Chris J. Johannsen
Dr. David J. Barr
Mr. Terry W. Barney

Inexpensive Methods of Analyzing and Utilizing Remote Sensor Data

I. Introduction

- A. Purpose of manual
- B. Applicable user organizations
- C. History of remote sensor analysis development
 - 1. Visual - mechanical
 - 2. Computer automatic

II. Data sources and types w/relative costs

- A. Photography - scales and resolution
- B. Imagery - system, scale and resolution

III. Appropriate Equipment w/relative costs

- A. Stereoscopes
- B. Light tables
- C. Additive and subtractive devices - Additive Color Viewer, Diazo
- D. Photographic Processing
- E. Microviewers
- F. Transfer devices - ZTS, Map-O-Graph
- G. Drafting - cartographic equipment

IV. Data Analysis Techniques

- A. Stereo photo interpretation
 - 1. Drainage
 - 2. Land cover - Land use
 - 3. Erosional Form
 - 4. Tone - texture
 - 5. Inference of Land form - parent material - Land resources, soils, geologic structures
- B. Monoscopic Image Interpretation - Landsat Multispectral SLAR
 - 1. Drainage
 - 2. Land cover - Land use
 - 3. Topo. Form
 - 4. Tone - texture
 - 5. Inference of Land form - Parent Material - soils, geologic structure, land resources

C. Enhancement Techniques - Spectral properties

1. Additive Color Viewer - masking
2. Diazo Processes - masking
3. Image enlargement procedures

V. Useful Applications

- A. Land Use - Land Resource Mapping
- B. Engineering Soils Mapping
- C. Geologic Mapping
- D. Water Resource Mapping
- E. Basic Land Resource Data Collection for Environmental Assessment
- F. Crop and vegetation mapping

VI. Summary Comments

- A. Relation of visual - mechanical analysis techniques to computer processing techniques

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